Fermilab

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Specifications for a 12 Megawatt (Peak) Klystron Amplifier

Specification #0230.00-ED-60830

May 9, 1988

Pulsed Klystron Amplifier: Description
12 megawatts (peak), 20.7 kW (average),
fixed tuned, sealed-off, 805 MHz, cathode pulsed,
electromagnetically focused, waveguide output,
coaxial input, water cooled, ion-pumped

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1.0 Specification #0230.00-ED-60830 For A 12 Megawatt (Peak) Pulsed Klystron Amplifier Tube

2.0 Scope

This specification establishes the requirements for the design, fabrication, testing and delivery of a 12 Megawatt (peak) pulsed Klystron Amplifier consisting of one each of the following: Klystron Tube, Focusing Magnet, Klystron Tube Socket and Lead X-Ray Shielding Set. The Klystron Amplifier will be utilized in the upgrade of the Fermilab 200 MeV Linear Accelerator to an energy of 400 MeV.

3.0 Electrical Specifications

3.1 Center frequency (fixed tuned)............... 805 MHz

3.2 Output power peak (at center frequency)...... 12 MW, min.
into a resistive load with VSWR of 1.5:1
or less and any phase angle

3.3 Output power average........................ 20.7 kW

3.4 Pulse duration, rf.......................... 115 micro sec

3.5 Pulse duration, video between 90% points..... 128 micro sec
rise time.................................... 9 micro sec
fall time.................................... 18 micro sec

3.6 Pulse repetition rate........................ 15 Hz

3.7 Gain, at saturation.......................... 50 dB nominal
45 dB min

3.8 Efficiency (at center frequency)............. 50% nominal
45% min

3.9 Instantaneous bandwidth at -0.5 dB points.... 4 MHz objective
3 MHz min

3.10 Electron gun perveance...................... 2 microperveance nom
1.75 microper min

3.11 Capacitance between cathode and body......... 75 pF max

3.12 Input match (-6 dB from and to saturation.... 1.5:1 VSWR max
with Klystron beam current "on")

3.13 Harmonic power at each harmonic.............. -30 dBc or better
with a resistive load VSWR of less than 1.15:1

3.14 Harmonic power at each harmonic.............. -27 dBc or better
at harmonic resonance of output circuit

3.15 Spurious power, total........................ -80 dBc or better

3.16 Phase sensitivity to beam voltage............ 10 deg/eb(%) nominal
change in percent 15 deg/eb(%)max

3.17 Phase drift as a function of inlet........... 3 deg/degree C max
cooling water temperature change

3.18 Peak inverse voltage of...................... 10% max to produce less than 3% amplitude jitter on backswing voltage

3.19 Amplitude modulation from heater............. 1% max

3.20 Amplitude drift as a function of inlet....... 0.2%/degree C max
cooling water temperature change

3.21 Phase modulation from heater................. 2 deg max

3.22 Amplitude sensitivity (beam voltage)......... 180 kW/kV nominal
250 kW/kV max

3.23 Phase shift with rf drive power change....... 5 deg/dB
from -6 dB below to saturation

3.24 The tube shall be used to provide 12 MW (peak) of rf power to a resonant cavity accelerator load having a Q of 25,000. The steady-state load VSWR during the pulse shall be 1.5:1 or less at arbitrary phase angle and a full power reflected transient with a decay time of 10. microsec. will exist at "turn on" and "turn-off" of the rf pulse. Maximum linearity of the rf power-in to rf power-out transfer curve in the upper third of the rf power output range before saturation shall be a design goal. The rf power delivered to the accelerator cavity load will be controlled over this range by a fast closed-loop feedback system to maintain the accelerating electric field and phase constant under various conditions.

3.25 Heater, ac voltage and current, surge........ To be specified by vendor
protection and warm up time

3.26 The dynamic gain shall not deviate more than 10 dB over the interval of rf output power from 6 MW to saturation, and shall not exceed 60 dB nor be less than 45 dB over this interval. There shall be no discontinuous changes in the rf power output when the rf drive is changed to produce output power over this interval at any time during the rf pulse.

4.0 <u>General Specifications</u>

4.1 Mounting position............................	vertical, cathode down
4.2 Collector....................................	grounded
4.3 Collector cooling............................	water gpm to be specified by vendor, 25 gpm nominal with return side pressure of 40 psi nominal, input water temp range 13 to 29°C available
4.4 Body cooling.................................	water gpm to be specified by vendor 5 gpm nominal with return side pressure of 40 psi nominal, input water temp range 13 to 29°C available
4.5 Base connection..............................	socket; part number (P/N) to be specified and supplied by vendor
4.6 RF input connection..........................	Mates with type "N" UG-21-D/U, or equiv
4.7 RF output connection.........................	WR-975 waveguide
4.8 Waveguide pressurization.....................	to be specified by vendor
4.9 Tuning.......................................	fixed (set at factory)

4.10 Ion pump size................................	to be specified and supplied by vendor
4.11 Ion pump connection..........................	to be specified by vendor if non-standard
4.12 Tube length (from the bottom of the base to top, including water connections)..............	116 inch max
4.13 Distance when mounted to focusing electromagnet between bottom of focusing electromagnet flange to top of klystron including water connections...........	97 inch max
4.14 Tube weight..................................	1200 lbs max
4.15 Tube x-ray shielding.........................	P/N to be specified and supplied by vendor
4.16 X-ray shield weight..........................	to be specified and supplied by vendor - 400 lbs max
4.17 Focusing electromagnet.......................	P/N to be specified and supplied by vendor
4.18 Focusing electromagnet diameter including mounting flange (water header and electrical boxes may protrude out an additional 8 inches)..............	26 inch max
4.19 Focusing electromagnet: weight...............	2000 lbs max
electrical power..........................	5000 W max
water cooling.............................	water gpm to be specified by vendor 5 gpm nominal with return side pressure of 40 psi nominal, input water temp range 13 to 29°C available

4.20 The rf-power output shall be through a WR-975 waveguide provided with a standard waveguide flange as shown on drawing #0230.00-ED-60830. The Klystron window shall be accessible for periodic inspection and cleaning from the output waveguide flange. Window-cooling air or water flow to be specified and shall be kept to a minimum, consistent with this specification.

4.21 The Klystron shall be mounted vertically, cathode end down. The cathode and tube socket will be immersed in a Marcol Special High Voltage Insulating Oil (or equivalent). Electrical gradients around cathode insulator and tube socket assembly shall be low enough so that no arcing will occur if the oil deteriorates to 25 kV when tested as specified in ASTM Standard D877.

4.22 The tube socket will be designed with spring loaded contacts and be designed to be mounted to the base of the magnet so that the Klystron can be removed without disconnecting leads or removing the magnet from the pulse transformer.

4.23 The design of the focusing electromagnet in the cathode region shall allow adequate free convective oil flow for necessary heat removal.

4.24 The magnet assembly shall be configured so that it can be readily lifted out of its packing crate with an overhead crane.

4.25 The Klystron assembly shall be configured so that it can be lifted and mounted to the magnet with a overhead crane. The assembly of the Klystron and magnet, thus formed, shall also be configured so that it can be lifted onto the pulse transformer tank by the use of overhead crane.

4.26 X-Ray shielding shall be provided so that when the tube is running at full power, the radiation level shall not exceed 2.5 mR/h anywhere within a radius of 18 inches from the tube and tube window when measured using a Victoreen 440-RF ionization chamber or equivalent.

5.0 Tests to be Performed by the Vendor Before Shipment

5.1 The following tests will be performed by the vendor at the vendor's plant prior to shipment to Fermilab:

5.1.1 With the filament set to rated voltage and current and with no rf drive signal and with the video pulse length set to a minimum of 40 microsec. on the vendor's rf test stand, measure and plot peak beam current versus cathode voltage for at least six equally spaced continuous 15 kV intervals up to the maximum specified cathode voltage. The plot on log-log paper shall be a straight line, and the perveance determined from this line will be as specified.

5.1.2 With the tube on the rf test stand and operating into a resistive calorimeter load (VSWR less than or equal 1.15:1) and with the pulse length as per 5.1.1 and at specified rf drive level and cathode voltage demonstrate:

1. Average power output greater than or equal to 20.7 kW.

2. Peak power output greater than or equal to 12 Megawatts.

3. Efficiency defined as peak rf power output divided by beam power input is greater than or equal to 45%.

4. That the dynamic gain does not deviate more than 10 dB over the interval of rf output power from 6 MW to saturation, and shall not exceed 60 dB nor be less than 45 dB over this interval and that there are no abrupt discontinuous changes in the rf power output when the rf drive is changed to produce output power over this interval at any time during the rf pulse. This shall be determined by plotting the rf input-power to output-power transfer curve from zero power output to full saturation output.

5. Compliance with noise specifications 3.13, 3.14 and 3.15.

5.1.3 With the tube on the rf test stand and operating into a load with VSWR=1.5:1 at six approximately equally spaced phase angles spanning 180 degrees and with a minimum 40 microsec pulse length and at specified rf drive level and cathode voltage, demonstrate compliance with dynamic gain specification 3.24.

6.0 Tests to be Performed at Fermilab for Final Acceptance

6.1 The following tests will be performed at Fermilab by Fermilab personnel to determine final acceptance:

6.1.1 With the filament set to rated voltage and current, and with no rf drive signal, and with the video pulse length set to electrical specification 3.4 (125 microsec) on Fermilab's rf test stand, Fermilab will measure and plot peak beam current versus cathode voltage for at least six equally spaced continuous 15 kV intervals upto the maximum specified cathode voltage. The plot on log-log paper shall be a straight line, and the perveance determined from this line will be as specified.

6.1.2 With the tube on the Fermilab's rf test stand and operating into a resistive calorimeter load (VSWR less than or equal 1.15:1) and with the pulse length as per 3.4 and at specified rf drive level, pulse length and cathode voltage demonstrate:

1. Average power output greater than or equal to 20.7 kW

2. Peak power output greater than or equal to 12 Megawatts

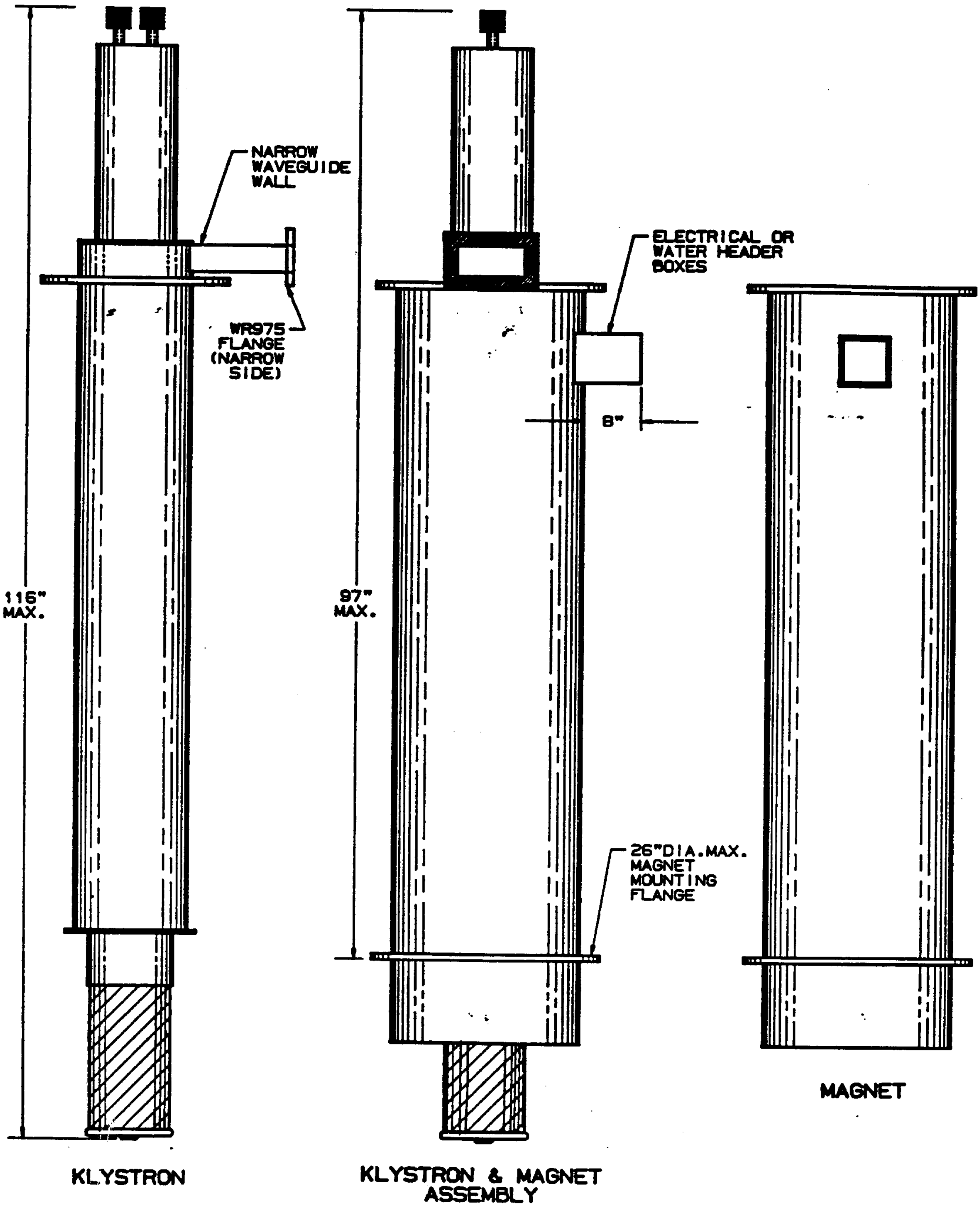
3. Efficiency defined as peak rf power output divided by beam power input is greater than or equal to 45%

4. That the dynamic gain does not deviate more than 10 dB over the interval of rf output power from 6 MW to saturation, and shall not exceed 60 dB nor be less than 45 dB over this interval and that there are no abrupt discontinuous changes in the rf power output when the rf drive is changed to produce output power over this interval at any time during the rf pulse. This shall be determined by plotting the rf input power to output power transfer curve from zero power output to full saturation output.

6.1.3 With the tube on the rf test stand and operating into a load with VSWR=1.5:1 at six approximately equally spaced phase angles spanning 180 degrees and with a 125 microsec pulse length and at specified rf drive level and cathode voltage demonstrate compliance with dynamic gain specification 3.24.

7.0 Operating Environmental Conditions and Tube Lifetime Objectives

The Klystron amplifier equipment will be operated at Fermilab to power a resonant cavity for the acceleration of charged particles. The equipment must be designed to operate continuously at the nominal specifications listed in this document. The equipment will be installed and operated in a laboratory building with the temperature, humidity and dirt controlled so as not to limit the lifetime of the installed equipment. An important objective of the design will be a long lifetime, hopefully in excess of 40,000 hours, for the tube and cathode. As-built manufacturing tube drawings, special handling, operating and maintenance instructions must be provided with the delivery of the equipment from the vendor. Another objective of the design will be to provide the capability for rebuilding the tube.



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